# EDAPHIC MESOFAUNA COMMUNITY STRUCTURE IN SOME ECOSYSTEMS AFFECTED BY INVASIVE PLANTS IN THE DANUBE DELTA BIOSPHERE RESERVE

**Adina CĂLUGĂR**[1]

e-mail: adina.calugar@icbiasi.ro

**Abstract**

Edaphic mesofauna is involved in decomposition and mineralization of organic matter and the regulation of nutrient cycles. These organisms are associated with soil quality and plants diversity. Invasive alien plants into an ecosystem can determine dramatic changes in both the native plant and animal assemblages. Consequently, the purpose of the article is to highlights a potential influence of invasive species (*Elaeagnus angustifolia, Amorpha fruticosa, Ailanthus altissima, Vitis vinifera, Cannabis ruderalis*) on the quantitative and qualitative parameters of the edaphic mesofauna, on the main systematic and trophic groups. Among mites oribatids are predominant in almost of the investigated plots with a maximum of 84% in the plantation with Canada poplar and *A. fruticosa*. Another group of mites, the *Trombidiformes* characterized by a various trophic regime, is also with high densities, the highest one being registered in the ecosystem with *A. altissima* (78%). The ratio between some groups (oribatids/ collembolans, oribatids/ astigmatids) which is considered a good bioindicator of the quality and humification stage of an organic substrate was with high values in all the examined plots. These results have shown that humification is predominant, and the nutrient cycle is slower in all investigated plots. It is remarked a small number of collembolans in all analysed samples and also, an absence of this decomposer group of mesofauna, a group that generally has a high share in the whole fauna of edaphic microarthropods, especially in good humidity conditions.

**Key words**: microarthropods, alien plants, Danube Delta

Nowadays, it is unanimously recognized that invasive plants represent one of the major threats for biodiversity, human health and even for economy. These plants grow spontaneously in the newly occupied territory, rapidly multiply and cause even the extinction of some native species and finally may modify the ecosystem functions as well. At the edaphic level, the invasive plants may change the chemistry, lead to a decreased fertility, may affect mycorrhizal fungi, etc.

In a publication from 2011, Sirbu C. and Oprea A. specify that in Romania 671 non-native species of plants were inventoried, of which 112 species gather the criteria for an invasive status, due to both their spread capacity, as well as the impact they have. In the last hundreds of years, the Danube Delta has been also invaded by many invasive plants, which have a negative influence on this unique ecosystem in Europe. According to Anastasiu P. (Anastasiu P. *et al*, 2014) on the territory of Danube Delta Biosphere Reserve exists 168 non-native plants, of which 35 are considered invasive. Among them *Ailanthus altissima*, *Amorpha fruticosa* are aggressive having a negative impact on different ecosystems (Anastasiu P. *et al*, 2014). The botanical researches are very numerous, but the same cannot be said about researches of edaphic microarthropods fauna from the perimeters with invasive plants. In Europe, a relevant research has been conducted in Silesian province, south Poland on the influence of the highly productive invasive species *Fallopia sachalinensis* (=*Reynoutria sachalinensis*) on edaphic microarthropods fauna (Skubala P., Mierny A., 2009). Other works are on ccommunities of mites in litter and soil under the invasive red oak (*Quercus rubra* L.) (Kohyt J., Skubala P., 2013) or on the *Collembola* and *Acari* communities under *Impatiens glandulifera* (Rusterholz H.P. *et al*, 2014).

In our country, only one study is dedicated to the fauna of edaphic microarthropods from surfaces covered by invasive plants and is related to the fauna associated with *Reynoutria japonica* from the Maramureș Mountains Natural Park. The respective investigation was carried out in different climatic conditions, but only arachnids and collembola were analysed (Hapca I.A, 2014).

[1] Institute of Biological Research Iași, Branch of National Institute of Research & Development for Biological Sciences, Bucharest, Romania

Therefore, the present article, by the quantitative and qualitative investigation of the fauna of edaphic microarthropods on main systematic and trophic groups from invaded perimeters, compared to the non-invaded ones is a novelty for our country, and the investigation within D.D.B.R. could be a starting point for similar research in other parts of the country.

## MATERIAL AND METHOD

Sampling was performed in June 2019 from eight different plots, six of them with invasive species (*Elaeagnus angustifolia, Amorpha fruticosa, Ailanthus altissima*, *Vitis vinifera, Cannabis ruderalis*) from four localities placed on the D.D.B.R. territory, as follows:

- Pătlăgeanca (1) (45°12′54.6″N 28°41′41.0″E), an area with *E. angustifolia* (E.a.) and one meadow without this invasive plant (mw.);

- Plauru (2) (45°16′31.4″N 29°39′21.8″E) one young plantation (pl.) of *Salix alba* (S.a.), *Populus alba* (P.a.) and *A. fruticosa* (A.f.) and an old plantation (pl.) of *Populus x canadensis* (P.c.) with *A. fruticosa* (A.f.);

-Beștepe (3) (45°05′15″N 29°02′26.76″E) a perimeter with *A. altissima* (A.a.) and an abandoned vineyard (*V. vinifera* – V.v.);

-Sabangia (4) ( 44°58′30″N 28°52′59″E) area with *C. ruderalis* (C.r.) and an adjacent meadow (mw.).

In all these plots there were taken series of five samples. In the plot with *E. angustifolia* and in that with Canada poplar the samplings were collected on two subhorizons – olf (litter and fermentation layer) and ah (humification layer). Each sample had an area of 100 $cm^2$. The edaphic mesofauna was extracted by Tullgren – Berlese method, then it was sorted on groups: *Parasitiformes* (*Mesostigmata*, inclusively *Uropodina*), *Acariformes* (*Trombidiformes* and *Sarcoptiformes* - *Oribatida* subdivision and *Astigmatina* cohort), an order belonging to the class *Entognatha* (*Collembola*) and insects as a whole.

## RESULTS AND DISCUSSIONS

Investigations of the effects of invasive plants on arthropod species richness and abundance yielded conflicting results. Thus, some studies have reported an increased diversity or abundance in invaded habitats (Sax D. F., 2002*;* Pearson D. E., 2009; Liu W. P. A. *et al*., 2012), while in others was found a reduced arthropod diversity or abundance (Topp W. *et al*. 2008; Wu Y. T. *et al*. 2009), or even no effect on arthropod abundance (Wardle D. A. *et al*., 1995; John *et al*., 2006) (Rusterholz H.-P. *et al.*, 2014).

An interesting idea, which could be a pertinent explanation of the results obtained in the present study, emerges from the researches contained in a Ph D thesis (Hapca I. A., 2014). In the chapter dedicated to edaphic microarthropods, the author discusses and tries to explain the influence of *R. japonica* on mite and *Collembola* populations. The densities of the mite and *Collembola* populations in the soil of a meadow and that of a perimeter invaded with *R. japonica* in conditions of drought, but also of abundant precipitations were compared. Regarding of the environmental conditions, it was found that the number of the mites increases in the soil covered by *R. japonica*; this is statistically assured in the case of sufficient precipitations. The number of collembolans increases with a significantly positive difference in both analysed perimeters in case of an optimal humidity. In drought conditions, the number of collembolans increases in the area with *R. japonica* by a percentage of over 20% compared to the meadow area (but not statistically assured difference). Therefore, it is considered that if precipitation is lacking, *R. japonica* keeps the soil shady and cold, so that springtails and mites keep their effectives, while in the meadow, the effectives of microarthropods are diminished. On the other hand, in the conditions of a rainy season, the number of collembolans decreases drastically in the perimeter with *R. japonica*, compared to the meadow, the statistical difference being strongly negative. In the present study it can also be observed that it is a higher density in soils with invasive plants compared to the adjacent meadows with no invasive plants (*table 1*). Thus, at Pătlăgeanca, in the perimeter with *E. angustifolia*, the total density of the mesofauna is almost 3 times higher than in the meadow. The same situation was found at Sabangia where in the perimeter invaded by *C. ruderalis* the density of edaphic mesofauna is about 2 times higher compared to the neighbouring meadow (*table 1*). Another possible explanation would be that invasive plants provide an increased intake of necromass, on the basis of which mesofauna groups can develop. In addition a high diversity of litter in different stages of decomposition provides a greater diversity of niches for occupation by soil organisms (Makulec K. I. *et al*., 2006; Morais J. W. *et al*., 2010). Also, it is well known that there are differences in soil fauna abundances between forests of different age classes (Johansson T. *et al*., 2016). Thus, in the case of the plantations from Plauru, both of them invaded by *A. fruticosa*, it was found that the mesofauna abundance is the highest in the soil of the oldest plantation (the poplar Canada one).

Table 1
**Average density (individuals/100cm²) of the edaphic microarthropods from the analyzed agroecosystems**

| Taxa Locality/ Invasive plant/ecosystem | | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | E. a. | mw. | pl.+A.f. | | A.a. | V.v. | C.r. | mw. |
| | | | | P.a , S.a. | P.c. | | | | |
| ***Mesostigmata*** | | 6.4 | 6.8 | 1.2 | 1.4 | 1.8 | 24.4 | 2.2 | 0.8 |
| *Trombidiformes* | | 76.8 | 19.2 | 32.4 | 29.6 | 73.8 | 27.8 | 37.6 | 24.6 |
| *Sarcoptiformes* | *Oribatida* | 48.4 | 25.6 | 82.6 | 169.4 | 18.8 | 36.6 | 22.0 | 8.0 |
| | *Astigmatina* | 1.8 | 0.6 | 6.8 | 0.4 | 0.4 | 2.2 | 5.4 | 5.6 |
| **Total *Acari*** | | **133.4** | **52.2** | **123.0** | **200.8** | **94.8** | **91.0** | **67.2** | **39.0** |
| *Entognatha* (*Collembola*) | | 10.8 | 0.8 | 0.2 | 0.6 | 0.4 | - | 0.6 | - |
| *Insecta* | | 24.4 | 4.0 | 4.0 | 0.4 | 4.6 | 10.2 | 1.0 | 0.6 |
| Other groups | | - | - | - | 0.8 | - | 0.4 | 0.2 | - |
| **Total** | | **168.6** | **57.0** | **127.2** | **202.6** | **99.8** | **101.6** | **69.0** | **39.6** |
| O/C | | 4.48 | 32.0 | 413.0 | 282.33 | 47.0 | - | 36.66 | - |
| O/As | | 26.88 | 42.66 | 12.14 | 423.5 | 47.0 | 16.63 | 4.07 | 1.42 |

Legend: 1-4 sampling localities, see abbreviation in § Material and method

Here the density is 1.6 times higher than that observed in the young plantation with *Populus alba*. At the same time, the largest number of microarthropods in the whole series of considered ecosystems was identified here (*table 1*).

Many studies have shown that *Collembola* and *Acari* are among the most abundant and diverse microarthropods in the litter and soil of numerous ecosystems accounting for about 95% of the total number of arthropods in these strata (Hardings D. J. L., Stuttard R. A., 1974; Maraun M., Scheu S., 2000). According to a review, *Collembola* are the most numerous hexapod arthropods on the planet, including insects; they are particularly sensitive to environmental changes, and therefore thought to be an excellent bioindicator (Hopkin P., 1997). *Collembola* have an important role in plant litter decomposition processes and in forming soil microstructure. They are reported as being dominant in almost kinds of soils (Brahmann P. *et al.*, 2010; Zhu X. *et al.;* Abbas *et al.*, 2012, after Islam S. *et al.*, 2018). Abiotic factors are good predictors of collembolan community structure. The members of these diverse microarthropods group may be affected by changes in soil conditions and vegetation cover (Kaczmarek M., 1975; Hagvar S., 1982; Chauvat M. *et al* 2006 after Islam S. *et al.*, 2018). Their high abundance makes them significant contributors to several processes of soil, such as material and energy cycles, and formation of soil (Vu Q. M., Nguyen T. T., 2000, after Islam S. *et al.*, 2018). Our analysis reveals that collembolans are absent or present, but with a very small representation, being dominated by mites in high rates (79-99%) in both invaded or non-invaded plots. This situation can be explained especially by the dryness of the soil during the sampling period, springtails being very sensitive to this ecological factor.

Analysis of the mites fauna by taxonomic groups led to the finding that the oribatids and trombidiform mites has dominated alternatively (*table 1*).

At Pătlăgeanca, in the ecosystem invaded by *E. angustifolia* trombiforms, are the most abundant group with 46% of total, while in the meadow oribatid mites predominate (49%). At Plauru in both plantations – the young and the old one as well as at Beștepe in *V. vinifera* plot oribatid mites are on the first place with 67.15%, 83.61% respectively 40,2%. Trombidiform mites represent the majority in the rest of the plots, as follows: at Beștepe in the plot invaded by *A. altissima* (77.8%), at Sabangia, in the plot with *C. ruderalis* (55.95) and in the adjacent meadow (63.07%). *Trombidiformes*, a group of mites with a varied food regime (Krantz G. W, Walter D. E., 2009) are with a good representation status in meadows, meanwhile oribatids have the biggest abundance in forest ecosystems. With small percentages (0.59-26.59%) mesostigmatid mites hold third place within the *Acari*, because astigmatid mites have even smaller abundances with only one exception; in the plot invaded by *C. ruderalis* from Sabangia astigmatid mites were identified with a percentage of 8.03% and mesostigmatid with only 3.27%. The mites from *Astigmatina* cohort, is a microphytophagous group (Krantz G. W., Walter D. E., 2009), stimulated by wet and rich in organic matter (Călugăr M. *et al*, 1989). So, this group of mites find more proper condition for developing only in the soil invaded by *C. ruderalis* which is considered to be a eutrophic plant, thus preferring a soil rich in organic matter (Cuharscaia L., 2016).

The ratio between oribatids – O / collembolans – C as well as that of oribatids - O and astigmatids – As, indicates very high values, collembolans and astigmatid mites having sporadic presence and densities much lower than those of the oribatids. These results show the tendency towards intense humification in both invaded or non-invaded plots.

## CONCLUSIONS

The results of this research are based on only one sequence of time, so the conclusions have just a relative character. For complete conclusions the investigation must be repeated in some other climatic conditions at least. For the moment we can conclude that from a quantitative point of view there are differences between the perimeter invaded by invasive plants and the uninvaded neighbouring area, consisting in higher densities of the edaphic mesofauna in the first ones. From a qualitative point of view there were not detected any differences between them. Both climatic factors and soil properties (generally a sandy loam soil with a fine texture) have a cumulative negative effect on the density of Collembola population. Collembolans are absent or present with small densities in both invaded or uninvaded perimeters. Analysis of mites' fauna on taxonomic groups led to the finding that the oribatids and trombidiform mites have dominated alternatively and they are followed by gamasid mites with one exception when astigmatid mites are on third place. The ratio Oribatida / collembolans is supraunit, as well as the ratio Oribatida / Astigmatina, result which shows the tendency towards intense humification in both invaded or non-invaded plots.


## ACKNOWLEGMENTS

This his work was supported by the Romanian Ministry of Education and Research through the NUCLEU program (Contract no. 25N/2019/Project code 19-270301) and also, through the Program 1 - Development of the National R & D System, Subprogram 1.2 - Institutional Performance - Projects for Excellence Financing in RDI (Contract no. 22PFE / 2018). The author thanks to Dr. Ivan Otilia for provided the oribatid count.


## REFERENCES


**Anastasiu P., Negrean G., Smarandache D., Liţescu S., Basnou C., 2014 -** *Neophytes in protected areas. Case study: the Danube Delta Biosphere Reserve,* Acta Horti Bot. București**,** 41: 41-68

**Călugăr M., Huţu M., Bulimar F., Donose-Pisică A., 1989** - *Aspects of the decomposition process from a grass fertilized with mineral nitrogen* (in Romanian)*,* St. cercet. Biol, ser. Biol. anim., 41(1): 37-47.

**Cuharscaia L., 2016** - *Taxonomic structure, ecology and impact of invasive plant species on the Chișinău ecosystem* (in Romanian)*,* Studia Universitatis Moldaviae, 1(91), 1857-498X, 103-107, available on-line at http://studiamsu.eu/wp-content/uploads/17.p.103-107_91_91.pdf

**Hardings D. J. L., Stuttard, R. A., 1974 -** *Microarthropods*, In Dickinson, C. H. and Pugh, G. J. F. (Eds). *Biology of phi litter decomposition*., Academic Press: London, 489-532 pp.

**Hapca I. A., 2014 -** *Influenţa speciilor de plante invazive asupra biodiversităţii ariilor protejate Studiu de caz: Reynoutria japonica în Parcul Natural Munţii Maramureşului*, PhD thesis abstract, Cluj Napoca, 13 pp.

**Hopkin SP., 1997** - *Biology of the Springtails (Insecta: Collembola)*, Oxford University Press, UK, 330 pp.

**Islam S**., **Hossain M., Hossain M., M Yasmin, 2018** - *Impact of climatic factors and soil quality on the abundance and population density of Collembola in the Rajshahi University Campus, Bangladesh,* Journal of Entomology and Zoology Studies, 6(1): 1119-1125.

**Johansson T, Hjältén J, Olsson J, Dynesius M, oberge J-M, 2016** - *Long-term effects of clear-cutting on epigaeic beetle assemblages in boreal forests.* For Ecol Manag 359: 65–73.

**Kohyt J., Skubała P., 2013** - *Communities of mites (Acari) in litter and soil under the invasive red oak (Quercus rubra L.) and native pedunculate oak (Q. robur L.)* Biological Lett., 50(2): 111–124, available on-line at: https://www.researchgate.net/publication/269474774

**Krantz, G., W., Walter, D., E., 2009** - *A Manual Of Acarology.* third ed., Texas Tech. University Press, 807 pp.

**Makulec, K.I.; Olejniczak, I.; Szanser, M. 2006**- *Response of soil micro and mesofauna to diversity and quality of plant litter,* European Journal of Soil Biology, 42: 244-249.

**Maraun M, Scheu S., 2000** - The structure of oribatid mite communities (Acari, Oribatida): patterns, mechanisms and implications for future, research, Ecography (Cop.), 23: 374–383.

**Morais J.W., Oliveira V.S., Dambros C.S., Tapia-Coral S.C., Acioli A.N.S., 2010** - *Soil mesofauna in different systems of land use soil in upper river Solimões* (in Portuguese, with abstract in English), AM, Brazil. Neotropical Entomology, 39: 145-152.

**Peredo, P., S., F., Parada, Z., E., Vega, C., M., Barrera, S., C., P.**, **2009** - *Edaphic Mesofauna Community Structure In Organic And Conventional Management Of Cranberry (Vaccinium Sp.) Plantations: An Agroecological Approach.*, Rev. Cienc. Suelo Nutr./J. Soil. Sci. PlantNutr., 9(3), 236-244.

**Rusterholz H.-P., Salamon J.-A., Ruckli R., Baur B., 2014** - *Effects of the annual invasive plant Impatiens glandulifera on the Collembola and Acari communities in a deciduous forest*. Pedologia, 57: 285-291.

**Sîrbu C. (coord.), Oprea A., 2011** – *Alien plants in the Romanian flora* (in Romanian)*,* Edit. "Ion Ionescu de la Brad", Iași, 733. pp.

**Skubala P., Mierny A., 2009** - *Invasive Reynoutria taxa as a contaminant of soil. Does it reduce abundance and diversity of microarthropods and damage soil habitat?,* Pestycydy/Pesticides, 1-2, 57-62.